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A. D. MELVIN, CHIEF OF BUREAU.

NOTES ON EXPERIMENTS WITH BLACKHEAD OF TURKEYS.^a

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INTRODUCTION.

In the summer of 1905 arrangements were made for certain co-operative experiments between the Rhode Island Agricultural Experiment Station and the Bureau of Animal Industry of the United States Department of Agriculture. The object of these experiments was to breed turkeys with the hope of producing, if possible, a strain that would be immune, or largely so, to the protozoan disease, enterohepatitis, commonly known as "blackhead."^b The cooperation was begun in August, 1905, which was too late for the inauguration of any new experiments in that year. The breeding season was practically over, hence there was no other course open than to continue the experiments already begun and to make preparations for the work of the next season.

The cooperation of the Bureau of Animal Industry at this juncture was of great value, however, in enabling the station to secure and train new assistants for the work, and in affording other material aid. As will be detailed later, new turkeys were purchased, yards and pens were made, and much apparatus was supplied before the opening of the ensuing season, much of which would have been impossible without such a combination of resources.

^a These experiments, conducted at the Rhode Island Agricultural Experiment Station by cooperation between that station and the Bureau of Animal Industry, may be considered of a preliminary character, but the results have such a practical bearing on the breeding and raising of turkeys in the United States that it is deemed advisable to publish them at this time. The work on the part of the Bureau was originally under the supervision of its Animal Husbandry Office, but has since been transferred to the Pathological Division.

^b For a detailed description of this disease see Bureau of Animal Industry Circular 5.

On July 15, 1906, the writer was called to work in another field, from which he returned the following December. The direction of the work in breeding was assigned September 1, 1906, to Dr. Leon J. Cole, but the experiments already planned were continued for the remainder of the season under the immediate supervision of William F. Kirkpatrick, who assumed the duties of assistant in July, 1905.

The pathologic work originally begun in the station is necessarily blended with the breeding operations performed in cooperation with the Bureau. Inasmuch as the results of the breeding work were not apparent until later in the season, or after the arrival of Doctor Cole, this report is confined to the pathologic features.

Preventive experiments, based upon the previous work on the board floor and in distant yards, were continued on a large scale, and a variety of feeding and exposure tests were made to obtain more certain knowledge of the method of transmission of the protozoon which produces the disease.

This work conflicted in no way with the breeding experiments, for the distant yards on the plain being uninfected were favorable to the rearing of the poults which could not otherwise have been reared, and care was taken to save the earliest poults of each lot for the breeding work. Other poults of the same lots were exposed to infection and furnished results in that line. At the same time they served as checks upon the main lot.

TURKEYS USED IN THE EXPERIMENTS.

The breeding stock for 1906 consisted of the station turkeys which had survived from the preceding year, also newly purchased individuals of standard breeds, and wild turkeys.

Little previous attention had been paid to the breeding further than to avoid close relationships and, when necessary, to resort to line breeding. The stock then on hand was esteemed especially valuable, for the reason that they had all escaped or recovered from the ravages of the protozoa and had been in the yards from one to three years. It was therefore possible that these turkeys possessed some degree of immunity.

Purebred stock was bought for the purpose of improving the appearance of the flocks, and to give each variety a trial as to its especial resisting powers. The only way of judging whether the turkeys which were purchased had been exposed to the disease was by noticing the breeder's degree of success in raising them.

Wild turkeys were acquired for use in combating the disease for the reason that they have been claimed to possess greater vigor and resisting powers than domestic turkeys.

In pursuance of the general plan, Mammoth Bronze and White Holland turkeys were purchased in Illinois, and some Narragan-

sett turkeys which came from Indiana, but had been in Rhode Island for a year, were also used. The latter had escaped infection on the farm, where most of their poults had died, presumably of blackhead, during the year 1905. No further varieties were purchased on account of the limited capacity of the yards.

The matings were made up chiefly as pens with one tom and four hens to a yard. In this way the collection and numbering of the eggs could be accomplished with a minimum amount of labor.

The hen turkeys were allowed to nearly hatch out their poults. The eggs were then taken from them and hatched in incubators, after which the poults were placed in brooders.

EXPERIMENTS ON UNINFECTED GROUND.

The table on page 8 gives the principal facts regarding the location, the numbers of the yards and lots, the time of exposure, the number and age of the poults dying of blackhead, the number succumbing to other ailments, and the number successfully reared.

Out of the 217 poults taken to the plain, which was quite a distance from the poultry plant and which had never before been used for turkey raising, 132 were reared, 27 died of the protozoan disease, and 58 of other troubles arising mainly from the brooding. The loss due to blackhead amounted to about 17 per cent. While more fortunate conditions might have entirely prevented the disease, the outcome is very satisfactory in many ways.

A comparison between this experiment and those of 1905, when most of the poults were kept around the poultry plant, shows improved conditions, for in the earlier experiments less than 17 per cent were raised.

The comparatively long interval between the time of hatching and the appearance of the disease establishes positively that the protozoa are not transmitted through the egg. It also does away with the idea that the food, of whatever character, is the direct cause of the disease. It may, nevertheless, be an accidental carrier of the parasite; and if a poult has been attacked by the protozoa, heavy and indiscreet feeding may greatly lessen the chance of recovery.

Inasmuch as wild, half-wild, Narragansett, Bronze, Mammoth Bronze, White Holland, and mongrel turkeys all entered into the experiments and all suffered loss, it seems clear that no decided amount of immunity was possessed by any of them. The immunity that was expected from parents that had recovered from the disease, as was presumably the case with some of the station turkeys, was also not apparent.

The experiments further sustain the statement that turkeys may be raised and matured in marketable condition on a limited range. Further experiments must be made to show whether such conditions are

profitable even where high prices prevail. Extensive range where the birds can not acquire contagion from a poultry plant may no doubt be the most economical where the conditions for it are favorable. But the conditions herein described are the only ones under which any considerable number of turkeys have been carried to the marketing point at the station, and are those which at the present time offer encouragement in breeding.

INFECTION EXPERIMENTS.

Contemporaneously with the experiments in preventing the poults from becoming diseased, a number of others were tried to ascertain the direct source of the parasites or at least to learn the conditions under which the poults could acquire them.

In one experiment earthworms, both from supposedly uninfected and from infected places, were used; in another, dirt was employed which was contaminated with droppings and viscera from a diseased turkey; in another, the poults were exposed directly to soil; in others, they were exposed to the ground while being brooded by hens or turkeys; in others, they were kept on board floors or cement runs while brooded by hens or turkeys; and in others, an attempt was made to definitely infect ground by droppings from fowls.

The results of these various experiments were both negative and positive. Even in the latter cases there were at times intruding factors which may have influenced the result and which certainly made the interpretation more difficult. When considered in their entirety, however, they indicate strongly that the poultry yards are heavily infected; that chickens, though rarely affected with blackhead disease, may be the most potent factor in its dissemination, and that diseased turkeys are nearly or quite as serious a source of infection as chickens.

The great difference in results between these experiments and those on the plain as regards the number of poults reared demonstrates that something has been learned of the disease, and that while it was neither completely prevented in the first instance nor satisfactorily conveyed to the poults by feeding in the second much progress has been made.

With our present knowledge poults may occasionally be raised free from blackhead, and these birds can serve as valuable material for future experiments in methods for avoiding the disease. If the disease can be avoided, it will be more satisfactory than to attempt merely to make cures by medicinal treatment, although this is an attainment greatly desired by many poultrymen.

WORM-FEEDING TESTS.

Fifteen poults, part of the same lot as IVa and IVb (see table), were not taken to the plain, but were divided into three equal lots and

placed on June 9 in as many small pens in a house at the poultry plant. All were fed alike, except as to earthworms.

Lot IVc.

Five poults were fed twice daily from June 20 to July 1 on earthworms from a locality presumably uninfected. These were transferred June 30 to the chestnut woods, where they were placed in a colony coop with a board-floor run.

Two died of weakness July 1, but showed no signs of blackhead. The three remaining were put into yard No. 20 on July 21 with a number of others. The first appearance of disease in yard No. 20 was on August 11.

Lot IVd.

Five poults were used as checks on lots IVc and IVe, beginning June 9. They were transferred to a colony coop with a board floor in the chestnut woods.

One weak-boned poult was killed July 1 and a second July 10, but no blackhead disease was found. No blackhead developed in this lot before it was transferred to yard No. 20 on July 21, nor could it have developed prior to August 11, when the first poult died in that yard.

Lot IVe.

Five poults were fed on a few earthworms from the station yards on June 16. They were fed regularly twice a day from June 20 to June 30 on earthworms from the infected turkey yard No. 17. They were transferred to a colony coop with a board floor in the chestnut woods on June 30.

One died of blackhead July 1. Two out of three of this lot, when examined later, were found diseased before July 10, when the autopsy report was made. One died from an undetermined cause, not blackhead.

Although the check lot and those fed on earthworms from the uninfected yard were transferred finally to yard No. 20 instead of being killed and examined with the others, the evidence that earthworms from infected yards may kill poults, while others do not, is fairly conclusive. The earthworms in this instance were probably carriers of infected soil and were not necessarily a second host of the parasite.

Lot a.

Nine poults, part of a lot hatched August 26, were brooded in the house. Earthworms from supposedly uninfected ground were fed to them twice daily from September 15 to October 1, excepting on September 21 and 22. One died October 2 and three were killed

on account of weak bones October 17, but no protozoan disease was found in any of them.

Five were transferred to another experiment (IV*i*) on October 17, but although twelve were examined none of that lot seems to have died of blackhead, at least up to December 1.

Lot f.

Eight poults, part of the lot hatched August 26, were separated September 15 and brooded in the house. They were fed twice daily, excepting on September 21 and 22, on earthworms from an infected turkey yard No. 18, until October 1.

One poult died October 1 and two were killed October 17, but none showed any signs of blackhead. Five of them were transferred to lot IV*i* and formed part of the twelve referred to under lot *a*.

These experiments are positive in so far as they demonstrate that earthworms, even from infected yards, may not always carry the causative agent.

GROUND-EXPOSURE TESTS.

Lot VIa.

An A-shaped wire tent, 8 by 16 feet, was erected on the grass in the middle of the station poultry yard, at a point that must unquestionably have been crossed and recrossed by fowl and people. A small shed-roof coop was attached. A fowl with 3 naturally-hatched poults and 8 others from lots IV*a* and IV*b* were placed in this inclosure May 22, the date on which the first 3 were hatched. One died May 24, a second on May 26, and a third on May 28.

The first death from blackhead occurred June 9. A second poult died June 10, presumably of this disease, but the notes show that no examination was made. Six poults of this lot were sent for examination on June 11, and 4 of them were reported as infected with the disease.

During this time there had not been a single death from blackhead among 46 other poults of lots IV*a* and IV*b*, which were confined in the house, and but 4 from those lots were lost in the meantime from other causes. The first death due to blackhead that occurred in this lot of 46 was on August 21, or three months after hatching.

Whether infection in lot VI*a* came from the fowl or from the yard was undetermined, but other experiments, such as XI*b*, indicate that it could have occurred from either or both sources.

AN IMMUNITY EXPERIMENT.

Lot XIb, half-wild poults.

Five poults hatched on May 18, a part of a lot produced by crossing a domestic with a wild turkey, were placed on June 9, when 22 days

old, in the east end of the glass house which is attached to the station incubator house. A small run had been made for their reception by wiring a space about $3\frac{1}{2}$ by 10 feet extending across the end the entire width of the house. In past years hen manure had been applied to the soil, but no animals had gained access to it, save possibly rats.

One poult died and another was found on June 20 to have disappeared. Later it was found to have been dragged into a rat hole, where it had been eaten. A third poult died of blackhead on June 25, and the remaining two were then killed and found diseased and were used for experimental purposes. This experiment indicated that there was apparently no immunity conferred as a result of the wild-turkey blood in the poults, and, furthermore, showed that infection was probably due to the hen manure which had been spread on the soil.

Summary of the experiments for the year 1906.

EXPERIMENTS ON UNINFECTED GROUND (ON THE PLAIN).

| No. of lot. | Yard, etc. | When hatched. | Date and manner of exposure. | Number of poults. | Died brooding, etc. ^a | Died of blackhead— | | | | | | | Alive December 1. |
|-------------|---------------|---------------|------------------------------|-------------------|----------------------------------|--------------------|-------|---------|------------|----------|-----------|--------|-------------------|
| | | | | | | June. | July. | August. | September. | October. | November. | Total. | |
| XIa..... | Plain 1..... | May 18 | June 18..... | 10 | 1 | ... | ... | 2 | 1 | ... | 3 | 6 | |
| IVa..... | Plain 2..... | May 20 | do..... | 14 | 1 | ... | 1 | 1 | 1 | ... | 2 | 11 | |
| IVb..... | Plain 3..... | do | do..... | 14 | 2 | ... | ... | 1 | 1 | 1 | 2 | 10 | |
| XVa..... | Plain 4..... | May 26 | June 17..... | 22 | 4 | ... | 1 | 2 | 3 | 1 | 1 | 8 | 10 |
| IIa..... | Plain 5..... | May 20 | June 18..... | 13 | ... | ... | ... | 1 | ... | ... | 1 | 12 | |
| XVIa..... | Plain 6..... | June 2 | June 19..... | 17 | 5 | ... | 1 | 2 | ... | 2 | 5 | 7 | |
| XVIIb..... | Plain 7..... | do | do..... | 15 | 2 | ... | 1 | 1 | ... | ... | 1 | 12 | |
| Vd..... | Plain 8..... | June 10 | June 28..... | 12 | 2 | ... | ... | 1 | ... | ... | 1 | 9 | |
| XIc..... | Plain 9..... | do | do..... | 11 | 1 | ... | ... | ... | ... | ... | ... | 10 | |
| XId..... | Plain 10..... | June 16 | do..... | 11 | 7 | ... | ... | 2 | ... | ... | 2 | 2 | |
| IIIc..... | Plain 11..... | do | do..... | 13 | 1 | ... | ... | 1 | ... | 1 | 1 | 11 | |
| XIf..... | Plain 12..... | June 30 | July 20..... | 11 | 11 | ... | ... | ... | ... | ... | ... | 0 | |
| IIId..... | Plain 13..... | June 10 | July 26..... | 9 | 3 | ... | ... | ... | ... | 1 | 1 | 5 | |
| Ve..... | Plain 14..... | do | June 28..... | 11 | ... | ... | ... | ... | ... | ... | ... | 11 | |
| IVf..... | Plain 15..... | Aug. 4 | Aug. 25..... | 12 | 8 | ... | ... | ... | ... | ... | ... | 4 | |
| XVd..... | Plain 4..... | Aug. 2 | do..... | 5 | ... | ... | ... | ... | ... | ... | ... | 5 | |
| XVe..... | Plain 6..... | do | do..... | 6 | ... | ... | ... | ... | ... | ... | ... | 6 | |
| XIIc..... | Plain 17..... | July 3 | July 20..... | 11 | 10 | ... | ... | ... | ... | ... | ... | 1 | |
| Total. | ..... | ..... | ..... | 217 | 58 | ... | 2 | 6 | 11 | 7 | 1 | 27 | 132 |

INFECTION EXPERIMENTS.

| | | | | | | | | | | | | | |
|---------|------------------|--------|---------------------------------|----|---|-----|-----|-----|-----|-----|-----|-----|----|
| XIa.... | Plain 1..... | May 18 | June 18, soil of plain.. | 17 | 9 | ... | ... | 1 | 1 | ... | 2 | 6 | |
| XIb.... | Greenhouse..... | do | June 9, soil..... | 5 | 4 | 1 | ... | ... | ... | ... | 1 | ... | |
| IVa.... | Plain 2..... | May 20 | June 18, soil of plain.. | 15 | 3 | ... | 1 | ... | 1 | ... | 2 | 21 | |
| IVb.... | Plain 3..... | do | do..... | 17 | 4 | ... | ... | 1 | 1 | ... | 2 | ... | |
| IVc.... | Incubator house. | do | June 9, earthworms ^b | 5 | 2 | ... | ... | ... | ... | ... | ... | (c) | |
| IVd.... | do..... | do | Unexposed..... | 5 | 2 | ... | ... | ... | ... | ... | ... | (c) | |
| IVe.... | do..... | do | June 9, earthworms ^d | 5 | 1 | 4 | ... | ... | ... | ... | 4 | ... | |
| Vla.... | Station yards | May 22 | May 22, soil of station yards. | 11 | 5 | 6 | ... | ... | ... | ... | 6 | ... | |
| XVa.... | Plain 4..... | May 26 | June 17, soil of plain.. | 25 | 8 | ... | 1 | 2 | 3 | ... | 1 | 7 | 10 |

^a Number in this column includes all poults that died, or were otherwise disposed of, from time of hatching to December 1, regardless of their location.

^b These worms were from a presumably uninfected locality

^c Removed remainder.

^d These worms were from the infected turkey yards.

Summary of the experiments for the year 1906—Continued.

INFECTION EXPERIMENTS—Continued.

| No. of lot. | Yard, etc. | When hatched. | Date and manner of exposure. | Number of poults. | Died brooding, etc. | Died of blackhead— | | | | | | Alive December 1. | |
|--------------|-------------------|---------------|---|-------------------|---------------------|--------------------|-------|---------|------------|----------|-----------|-------------------|--------|
| | | | | | | June. | July. | August. | September. | October. | November. | | Total. |
| IIa | Plain 5..... | May 26 | June 17, soil of plain.. | 13 | a 4 | ..... | ..... | ..... | 1 | ..... | ..... | 1 | 8 |
| IIIa | Board-floor coop. | May 28 | May 31, fowl | 7 | 3 | ..... | 1 | 1 | ..... | ..... | ..... | 2 | (b) |
| XVIa | Plain 6..... | June 2 | June 19, soil of plain.. | 17 | c 5 | ..... | 1 | 2 | } | 2 | ..... | 6 | 19 |
| XVIIb | Plain 7..... | do | do..... | 15 | 2 | | | 1 | | | | | |
| Va..... | Board-floor coop. | June 6 | June 6, fowl..... | 8 | 1 | ..... | ..... | 2 | 3 | ..... | ..... | 5 | (b) |
| Vb..... | do..... | do | do..... | 10 | 5 | ..... | ..... | ..... | 1 | ..... | ..... | 1 | (b) |
| Vc..... | do..... | do | do..... | 8 | 2 | 1 | 5 | ..... | ..... | ..... | ..... | 6 | ..... |
| XVb..... | do..... | do | do..... | 7 | 2 | ..... | 1 | ..... | ..... | ..... | ..... | 1 | (b) |
| XVc..... | do..... | do | do..... | 8 | 2 | (?) 1 | 2 | 2 | ..... | ..... | ..... | 5 | (c) |
| Aa..... | A3 | June 8 | June 8, turkey hen and soil of arboretum. | 9 | d 7 | 1 | 1 | ..... | ..... | ..... | ..... | 2 | ..... |
| Ab..... | A1 | do | do..... | 9 | 1 | ..... | 1 | ..... | ..... | 1 | ..... | 2 | 6 |
| XIIa..... | A2 | do | do..... | 12 | 1 | ..... | ..... | 1 | ..... | 1 | ..... | 2 | 9 |
| XIc..... | Station yards | June 16 | June 16, soil of station yards. | 9 | f 8 | 1 | ..... | ..... | ..... | ..... | ..... | 1 | ..... |
| XId..... | Plain 10..... | do | June 28, soil of plain.. | 12 | 8 | ..... | ..... | ..... | 2 | ..... | ..... | 2 | 2 |
| XIc..... | Plain 8..... | June 10 | do..... | 13 | 3 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| IIIb..... | do..... | do | do..... | 5 | 3 | ..... | ..... | ..... | ..... | 1 | ..... | 1 | 11 |
| IIIc..... | Plain 11..... | June 16 | do..... | 17 | 1 | ..... | ..... | 1 | ..... | ..... | ..... | 1 | 15 |
| Vd..... | Plain 9..... | June 10 | do..... | 19 | g 10 | ..... | ..... | 1 | ..... | ..... | ..... | 1 | 18 |
| Ve..... | Plain 15..... | do | do..... | 11 | 1 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| IIb..... | Incubator house. | June 16 | Unexposed..... | 23 | 23 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| XIf..... | Plain 12..... | June 30 | July 20, soil of plain... | 9 | f 13 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| XIId..... | do..... | do | do..... | 4 |  | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| XIId..... | Plain 13..... | July 3 | do..... | 16 | 15 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 1 |
| XVd..... | Plain 6..... | Aug. 2 | Aug. 25, soil of plain.. | 6 | ..... | ..... | ..... | ..... | ..... | b 1 | } | 1 | 11 |
| XVe..... | Plain 4..... | do | do..... | 6 | | | | | | | | | |
| IVf..... | Plain 16..... | Aug. 4 | do..... | 17 | 13 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 4 |
| IVi..... | Incubator house. | do | Aug. 28, contaminated soil. ^h | 5 | 2 | ..... | ..... | ..... | 1 | ..... | ..... | 1 | (b) |
| Vf..... | Board-floor coop. | Aug. 13 | Aug. 13, fowl..... | 6 | f 5 | ..... | ..... | ..... | 1 | ..... | ..... | 1 | ..... |
| Vg..... | do..... | do | do..... | 9 | f 6 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| IVg..... | do..... | Aug. 14 | Aug. 14, fowl..... | 8 | f 6 | ..... | (?) 1 | ..... | 2 | 1 | ..... | 3 | ..... |
| IVh..... | do..... | do | do..... | 7 | f 6 | ..... | ..... | ..... | ..... | (?) 1 | ..... | 1 | ..... |
| a..... | Incubator house. | Aug. 26 | Sept. 15, earthworms i. | 9 | 6 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | (b) |
| f..... | do..... | do | Sept. 15, earthworms j. | 8 | 3 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | (b) |
| b..... | Board-floor coop. | Sept. 7 | Sept. 7, fowl..... | 7 | f 5 | ..... | ..... | ..... | ..... | 1 | ..... | 1 | (b) |
| c..... | do..... | do | do..... | 7 | f 7 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| d..... | do..... | do | do..... | 7 | f 7 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| e..... | do..... | do | do..... | 7 | f 7 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| i..... | do..... | Sept. 29 | Sept. 29, fowl..... | 2 | f 1 | ..... | ..... | ..... | ..... | ..... | ..... | 1 | ..... |
| T. C. R..... | ..... | June 11 | June 11, T. C. R's poultry yard. | 8 | f 6 | ..... | 2 | ..... | ..... | ..... | ..... | 2 | ..... |
| T. W. B..... | ..... | June 9 | June 9, T. W. B's farm. | 10 | ..... | ..... | 7 | ..... | ..... | ..... | ..... | 7 | 8 |
| Total..... | ..... | ..... | ..... | 495 | 238 | 14 | 21 | 14 | 19 | 14 | 1 | 83 | 144 |

^a These four sold November 15.^b Removed remainder.^c Two of these sold September 3.^d Five of these sent to Smith July 16 for examination.^e Remainder unaccounted for, lost.^f Exposed.^g One of these sold November 15.^h Diseased ceca, liver, and feces were added to supposedly virgin soil and the whole buried in greenhouse about August 1.ⁱ These worms were from presumably uninfected locality.^j These worms were from the infected turkey yards.

The foregoing table shows in condensed form the experiments of the year.

A study of the summaries of the two groups of experiments—those on the plain and those where infection was introduced purposely—show that in the former the greater number of deaths occurred in the third, fourth, and fifth months after hatching, but in the latter they were in the first, second, and third months.

Very little can be judged as to the brooding from these results, for those of the early and late season are so blended as to confuse them. An examination of the individual records for the early lots will show that artificial brooding may be quite successfully conducted. The infection experiments reinforce those on the plain in demonstrating that none of the varieties exposed was noticeably more immune than others.

The year's work also demonstrates the futility of attempting to use the station yards for breeding work unless large losses are expected. The breeding of the Bronze, White, and Mongrel turkeys was seriously interfered with by the death of both tom and hens in the breeding season. The yards offer, on the other hand, plenty of opportunities for continuing a study of conditions which favor the spread of the protozoa, providing that poults free from disease be raised under cover elsewhere for the various tests.

SUMMARY. .

The experiments for 1906, though not conclusive, indicate that:

1. The eggs do not carry the protozoon or organism which is the direct cause of blackhead or entero-hepatitis of turkeys.
2. Poults or adults become affected with the parasite at some period after they become exposed to contaminated surroundings. This period is usually within four weeks, and the poults most commonly die in from twelve to twenty-four days after exposure, although some may escape for months.
3. The ordinary fields, uncrossed by poultry, were probably not infected.
4. Poultry yards are heavily infected.
5. The chicken is a host of the causative parasites, and together with the adult turkeys spreads them broadcast through the droppings.
6. Poults may be successfully reared to maturity on comparatively small areas; passing with little or no loss through two marketable stages, namely, those of the broiler and small roaster.
7. The protozoa seem to be easily killed by drying, and dry sandy soils would therefore seem to be preferable for turkey raising.
8. No breed of turkeys thus far tested is immune to the blackhead disease, for all varieties at all ages, so far as tried, have died of it.

9. The older turkeys apparently resist the disease better than those which are very young, since about 20 per cent of the former have been found to die in the course of the year and about 90 per cent of the latter.

10. The experiments show that turkeys should be reared away from the house, and be kept from all fields where ordinary fowls forage.

Approved:

JAMES WILSON,
Secretary of Agriculture.

WASHINGTON, D. C., *November 6, 1907.*

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